

**Childbearing, Gestational Gain
And
Long-term Effects on
Women's Health:
Obesity and Chronic Disease**

**Erica P. Gunderson, Ph.D.
Research Scientist
Epidemiologist
Kaiser Permanente, Oakland, CA**

Two Sources of Data

1) Reproductive Age

- Childbearing – number of pregnancies and births
- Prospective studies examine change in risk factors from before to after pregnancy within 5-10 yrs
- Long-term impact of pregnancy on women's health independent of secular trends, aging and preconception risk factors.
- **Key aspects:**
 - Measurement of preconception risk factors: weight, waist girth, plasma lipids, glucose and insulin
 - Nongravid reference group
- **CARDIA Study (18-30 yr)**
50% Black and White,
USA population-based

2) Pregnancy cohort

- Characteristics of Pregnant and Postpartum women
- Prospective studies examine wt gain during and after pregnancy beyond 2 yr
- Identify the relative importance of maternal attributes associated with retention of gestational weight gain, postpartum weight change and development of obesity among pregnant women.
- **Key aspects:**
 - Measurement during pregnancy
 - Self-reported Pregravid weight
 - Lacks nongravid comparison
- **Perinatal Collaborative Study, Other Clinic-based samples**

Predictors of Postpartum Obesity

Before 1990

Since 1990 IOM

- **Modifiable attributes:**
 - Pregravid weight
 - Parity
 - Gestational weight gain
 - Age
 - Lactation

Few studies > 1 yr

- **Modifiable attributes:**
 - Pregravid body size (BMI)
 - Parity
 - Gestational weight gain
 - Age
 - Interval to first birth
 - SES
 - Lactation
 - Smoking
- **Fixed attributes:**
 - Race/ethnicity
 - Age at menarche
- **Design**
 - Preconception
 - Secular trends, aging

Long-term Weight Gain After Pregnancy

Pregravid BMI and Long-Term Weight Change

- **McKeown and Record, 1957**
 - By 12 mos postpartum weight change is largely influenced by the woman's weight before pregnancy; the heavier the woman the greater the weight 'retained'.
- **Billewicz, 1970**
 - Overweight women had greatest increases in body weight by the next pregnancy (1st birth).
- **Gunderson et al., 2001**
 - Higher long-term wt gain for obese women despite lower gestational gain.
 - No differences by race/ethnicity across BMI groups

Table 1: Long-term Excess Weight Gain after Pregnancy \geq 2 Yrs

Author, Year Study Period	n	Race, Primips (%)	Time Interval	Mean Weight Gain (kg)	Risk Factors
McKeown, 1957 Birmingham (1949-50)	289- 912	Whites (40)	2 Yrs (1 to 2 yrs)	3.0 0.3	High WT Parity
Billewicz, 1970 Aberdeen (1949-54)	5,265	Whites (100)	10 Yrs 1+ parity (20 th wk gest)	Underwt 0.8 Overwt 2.4	High BMI 1 st birth
Harris, 1999 South London (1990-93)	243	Whites (100)	>1 Yr (inter-preg)	NS 71% < 1.0	High BMI High GG
Gunderson, 2001 USA, UCSF (1980-90)	985	46% Minority (70)	70% > 2 Yrs (6 wks, > 2 yr) (inter-preg)	Underwt 2.2 Normal 2.4 Overwt 4.4 Obese 4.3	High BMI High GG

GG= gestional weight gain

Figure 1: Pattern of maternal weight loss 3 to 24 mos PP by lactation (Adapted from McKeown & Record 1957)

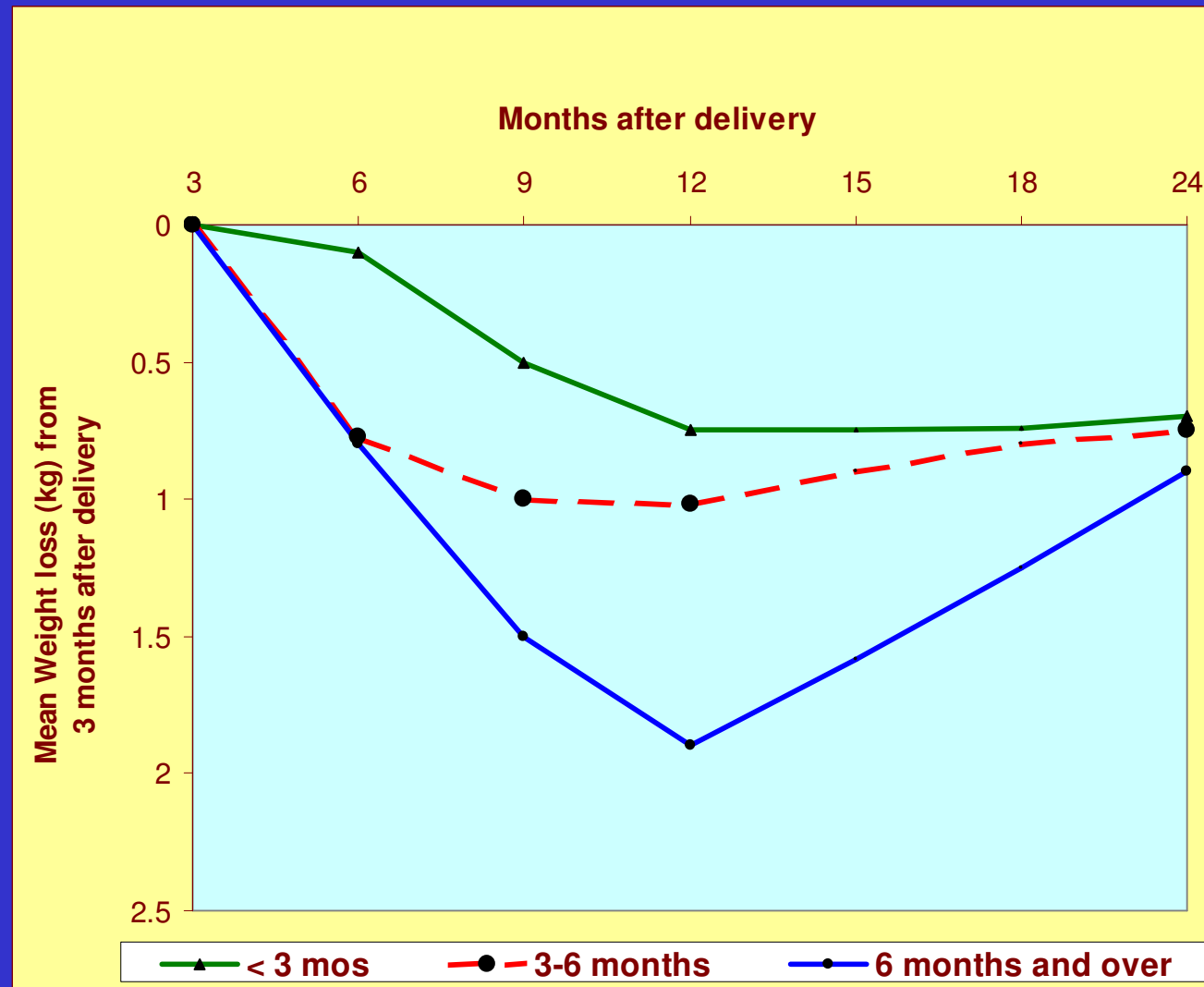


Table 2: Adjusted* Means for antepartum and postpartum weight changes by pregravid BMI group (*Gunderson et al. Int J Obes 2001*)

Weight Change Measures (kg)	Pregravid BMI Group at Index Pregnancy				p-value
	Underweight n = 266	Average n = 595	Overweight n = 71	Obese n = 53	
Gestational Net Gain (kg)	12.7 ± 0.3	13.0 ± 0.2	14.1 ± 0.6	10.8 ± 0.7	< 0.001
Early Net Postpartum WT (kg)	-6.2 ± 0.2	-6.4 ± 0.1	-6.3 ± 0.3	-6.2 ± 0.4	0.84
Late Postpartum WT (kg)	-4.2 ± 0.3	-4.2 ± 0.2	-3.4 ± 0.6	-0.3 ± 0.7	< 0.001

No interactions within BMI groups for race/ethnicity and weight changes. *Adjusted for: race/ethnicity, smoking habit, maternal age, parity, education, maternal height, hypertension of pregnancy, mode of delivery, and interval between pregnancies (late postpartum) or wks gestation (net gestational gain).

Note: For "Net" weight change measures infant birth weight has been subtracted out.

Figure 1: Patterns of maternal weight changes during gestation and postpartum periods by pregravid BMI (*Gunderson et al. Int J Obes 2001*)

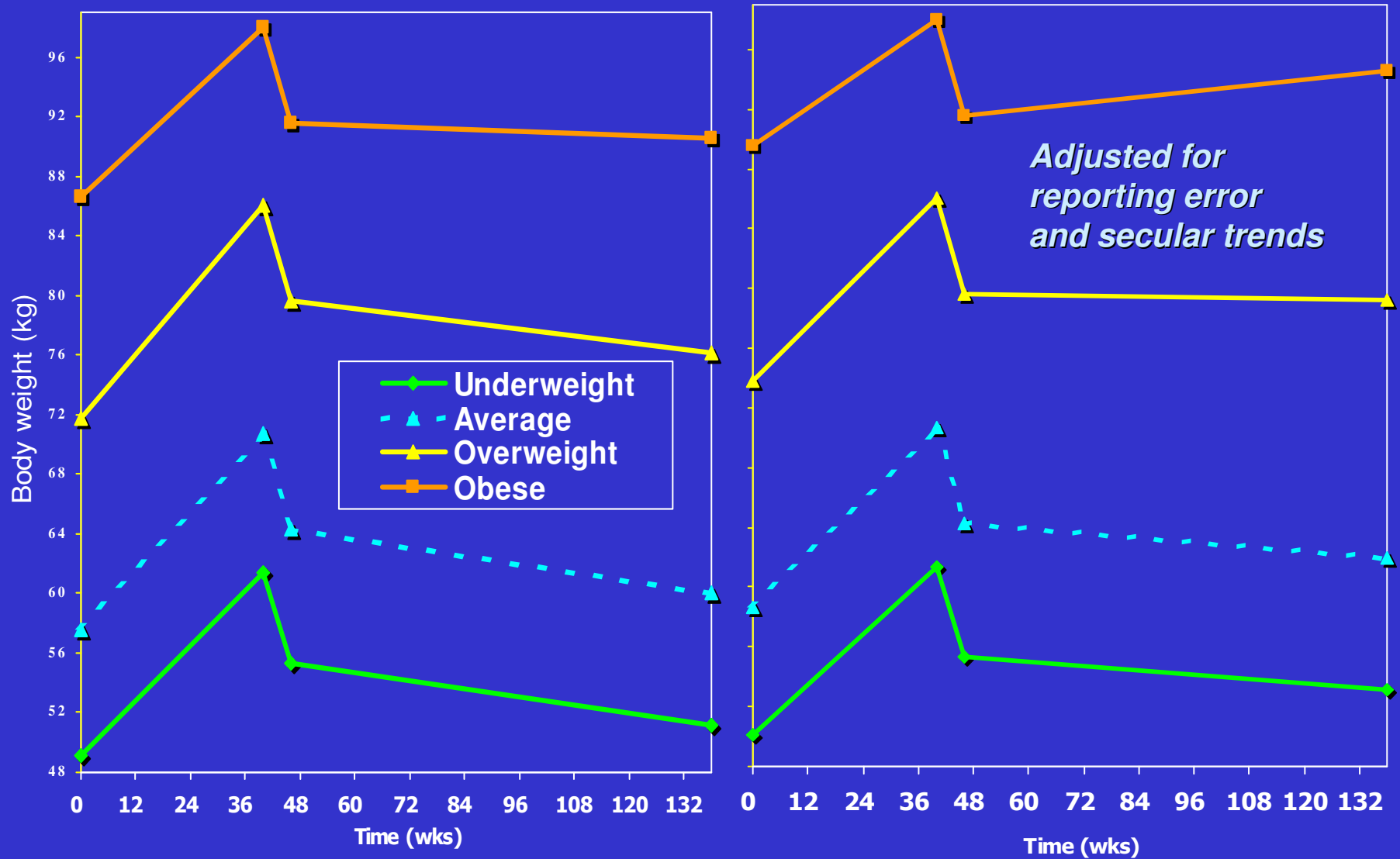
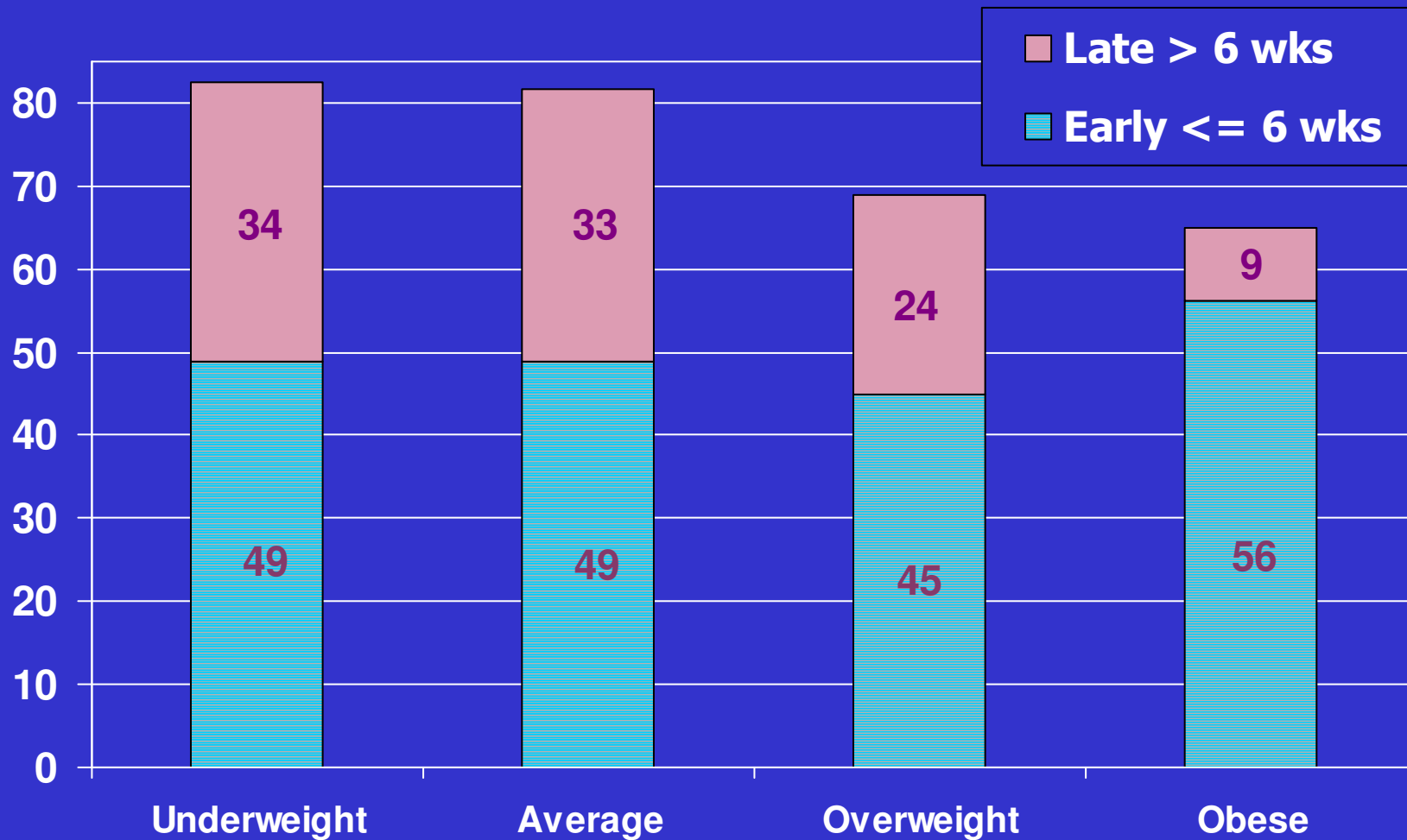


Figure 2: Net Early & Late Postpartum Weight Loss as Percentages of Net Gestational Gain by Pregravid BMI group. (*Gunderson et al. Int J Obes 2001*)



Incidence and Correlates of Becoming Overweight After Pregnancy

Table 1: Risk of Becoming Overweight >1 to 2 years After Delivery
(Pregnancy cohorts)

Author, Year Study	n	Race, (%)	Postpartum Period	Gestational Gain > IOM (%)	% Became Overweight or * PPWR > 9 kg (%)	
Parker & Abrams, 1993 1988 NMIHS USA(1985-91)	2119	Black (47) White	10 - 24 mos	32 12	14*	Blacks 22* Whites 8*
Ohlin, 1994 Sweden (1971-84)	1423	White (100)	12 mo	N/A	8	
Gunderson, 2000 UCSF Perinatal USA(1980-90)	1128	Minority (47)	median 2 Yrs	69	All	6.4 Whites 7 Hispanics 10 Blacks 10 Asians 2

Table 2: Adjusted OR (95%CI): Maternal Risk of Becoming Overweight.
(Gunderson et al. Int J Obes 2001)

Characteristic	Partial Variables Adjusted OR	n = 1102, Overwt = 71 95% CI	All Variables Adjusted OR	n = 987, Overwt = 62 95% CI
Gestational Gain				
Above IOM	3.19	(1.97 - 5.44)	2.95	(1.67- 5.24)
Within/Below IOM	1.00	Ref	1.00	Ref
Race/ethnicity				
Hispanic	1.40	(0.70 - 2.82)	1.27	(0.58 - 2.77)
Black	1.27	(0.56 - 2.89)	1.40	(0.59 - 3.29)
Asian	0.32	(0.14 - 0.72)	0.22	(0.08 - 0.65)
White	1.00	Ref	1.00	Ref
Maternal Age (yrs)				
18 - 23	0.75	(0.33 - 1.71)	0.61	(0.24 - 1.57)
24 - 30	1.90	(0.98 - 3.68)	2.49	(1.20 - 5.20)
> 30	1.00	Ref	1.00	Ref
Menarche to 1st Birth (yr)				
< 8	-----	-----	3.16	(1.43 - 7.00)
≥ 8	-----	-----	1.00	Ref
Age at Menarche (yr)				
≤ 12	-----	-----	2.57	(1.32 - 4.99)
> 12	-----	-----	1.00	Ref

Adjusted for: race, smoking, pregnancy-related HTN, education, parity, marital status.

Childbearing and Risk of Becoming Overweight OR (95%CI)

GUNDERSON et al, 2004

Race: Black vs White

Current Smokers: 2+ vs 0 births

Current Smokers: 1 vs 0 births

Never Smokers: 2+ vs 0 births

Never Smokers: 1 vs 0 births

WILLIAMSON et al., 1994

Obese (BMI >29) 1 vs 0 births

Moderate Overweight (BMI > 27) 1 vs 0 birth

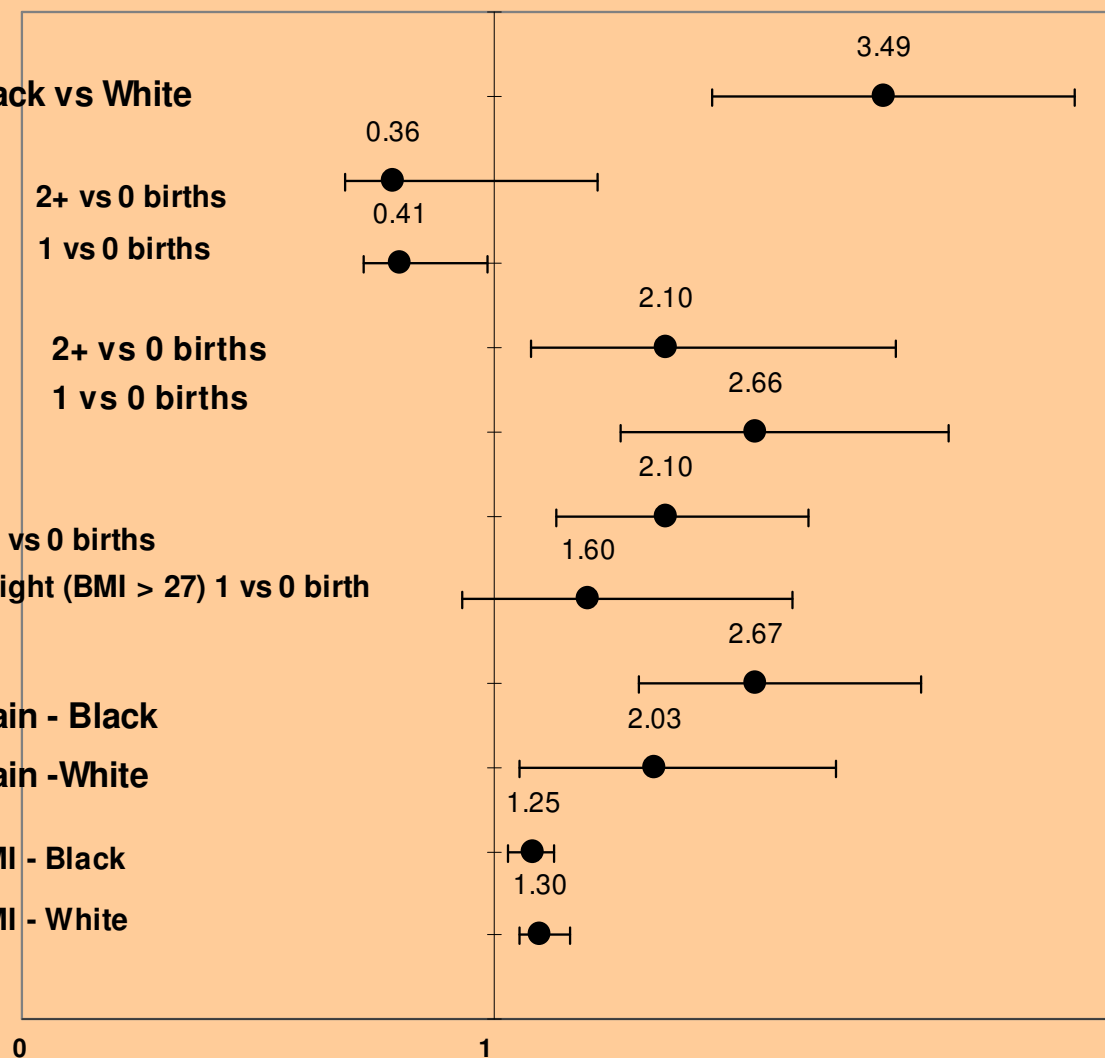
PARKER & ABRAMS, 1993

High Gest Wt Gain - Black

High Gest Wt Gain -White

Pregravid BMI - Black

Pregravid BMI - White



Gunderson 2004 – shows multivariate adjusted OR for race independent of no of births stratified by smoking status

Table 3: Pregnancy cohorts & Wt Gain 8 to 15 Yrs Later

Author, Year Study	n, Follow- up (%)	Race,	BMI >26 (%)	Study Time interval	Mean Wt Gain (kg)	Risk Factors
Rooney, 2002 Wisconsin USA	540/795 (68)	White	29	8-10 Yrs (1988–99)	6.8 (2.4 to 8.6)	High BMI 6 mo PPWR GG > IOM BF < 3 mo
Linne, 2003 Sweden	563/1423 (40)	White	5	15 Yrs (1971–84)	(4.3 to 11.7)	High GG 1 yr PPWR

PPWR = postpartum weight retention, GG = total gestational wt gain, BF = breastfeeding

Correlates of Substantial Weight Gain After Pregnancy (≥ 2 yrs) based on pregnancy cohort studies

- High pregravid body size
- Gestational weight gain $>$ IOM
- Primiparity
- Short Interval from menarche to first birth
- Menarche ≤ 12 y

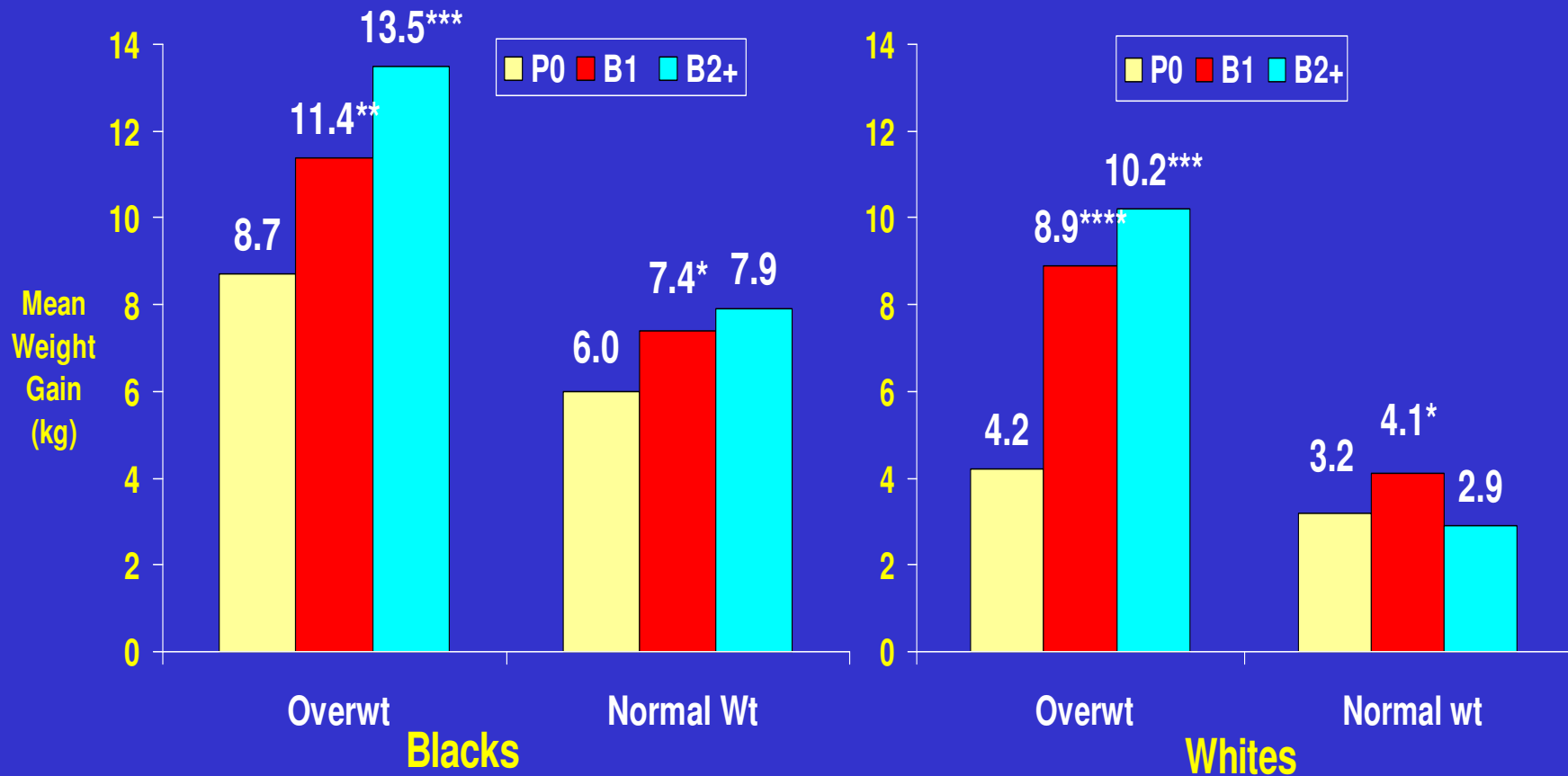
Childbearing:
Long-term Changes
in
Total and Central Adiposity

Table 1: Prospective Studies: Childbearing and Excess Weight Gain (nongravid referent & preconception measures)

Author, Year Study	Parous, n (n, Primips)	Race, Age range	Study Period	Excess Weight Gain (kg)
Williamson, 1994 NEFS, USA	308 (82)	White 25-45 yr	10 Yrs (1971-84)	Primips: 0 Multips > Nullips 1.7 per birth
Wolfe, 1997 NEFS, USA	413	86% White 25-45 yr	10 Yrs (1971-84)	Whites 0.5
Smith, 1994 CARDIA Study USA	203 (89)	50%Black/ white 18-30 yr	5 Yrs (1985-91)	Primips > Nullips 2 - 3
Gunderson, 2004 CARDIA Study USA	845 (557)	50% Black/ white 18-30 yr	10 Yrs (1985-96)	Primips > Nullips NL: 1 OV: 3 - 6

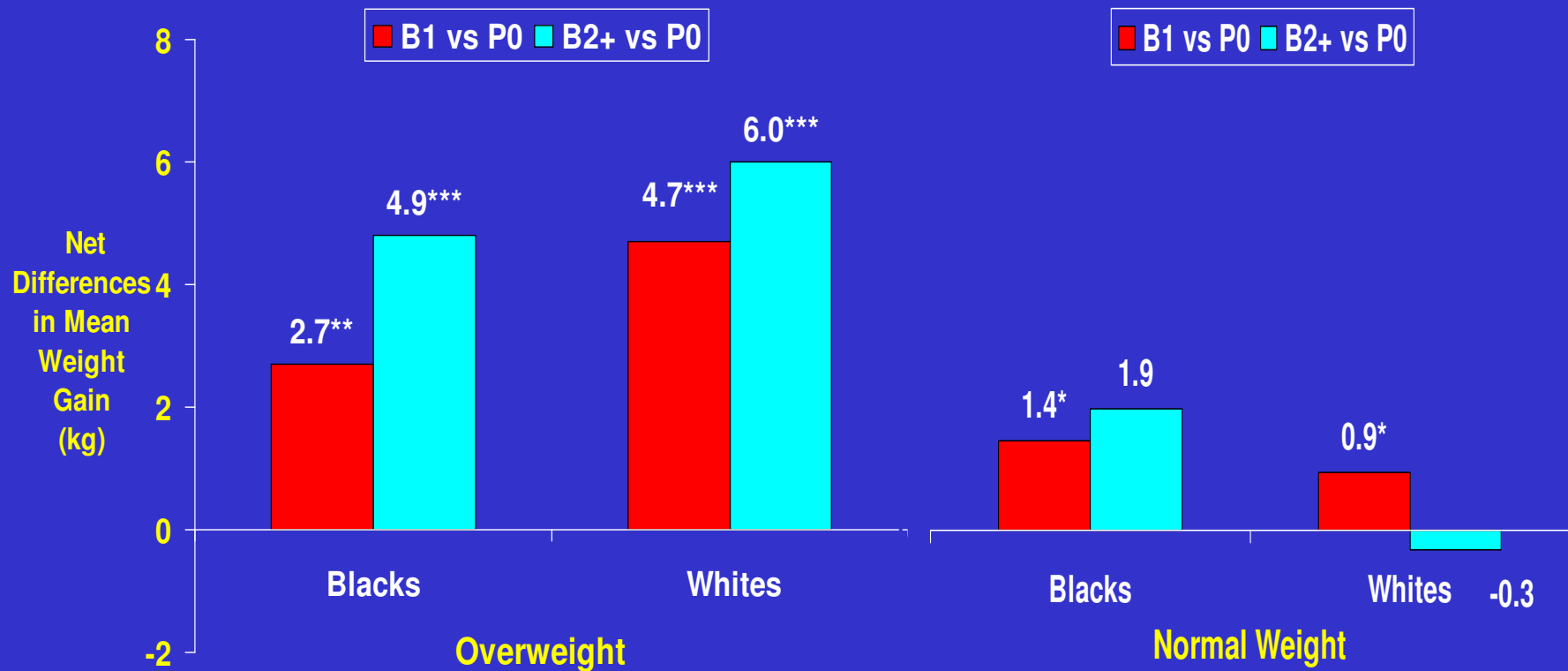
NL = normal weight (BMI <25), OV = overweight (BMI ≥ 25) at baseline before conception

Figure 1: Mean 10-yr Weight Gain (kg) by Interim Birth Groups (B1= 1 birth, B2+ = 2+ births vs P0 = nongravid) among Nulliparas at baseline; (* p-value <.05, ** <.01, ***<.001) (Gunderson et al. Int J Obes 2004)



Adjusted for center, age, height, baseline and time dependent variables (education, smoking status, physical activity, # pregnancies < 20 wks, & OC use)

Figure 2: Net differences in adjusted Mean 10-Yr Weight Gain (kg) among Interim Birth Groups (B1, B2+ vs P0) among Nulliparas at baseline by Race. (Gunderson et al. Int J Obes 2004)



Means (adjusted for center, age, height, and baseline and time dependent education, smoking status, physical activity score, # pregnancies < 20 wks, & OC use)

Table 2: Prospective Childbearing and Excess Weight Gain <3yrs (nongravid referent & self-reported weights)

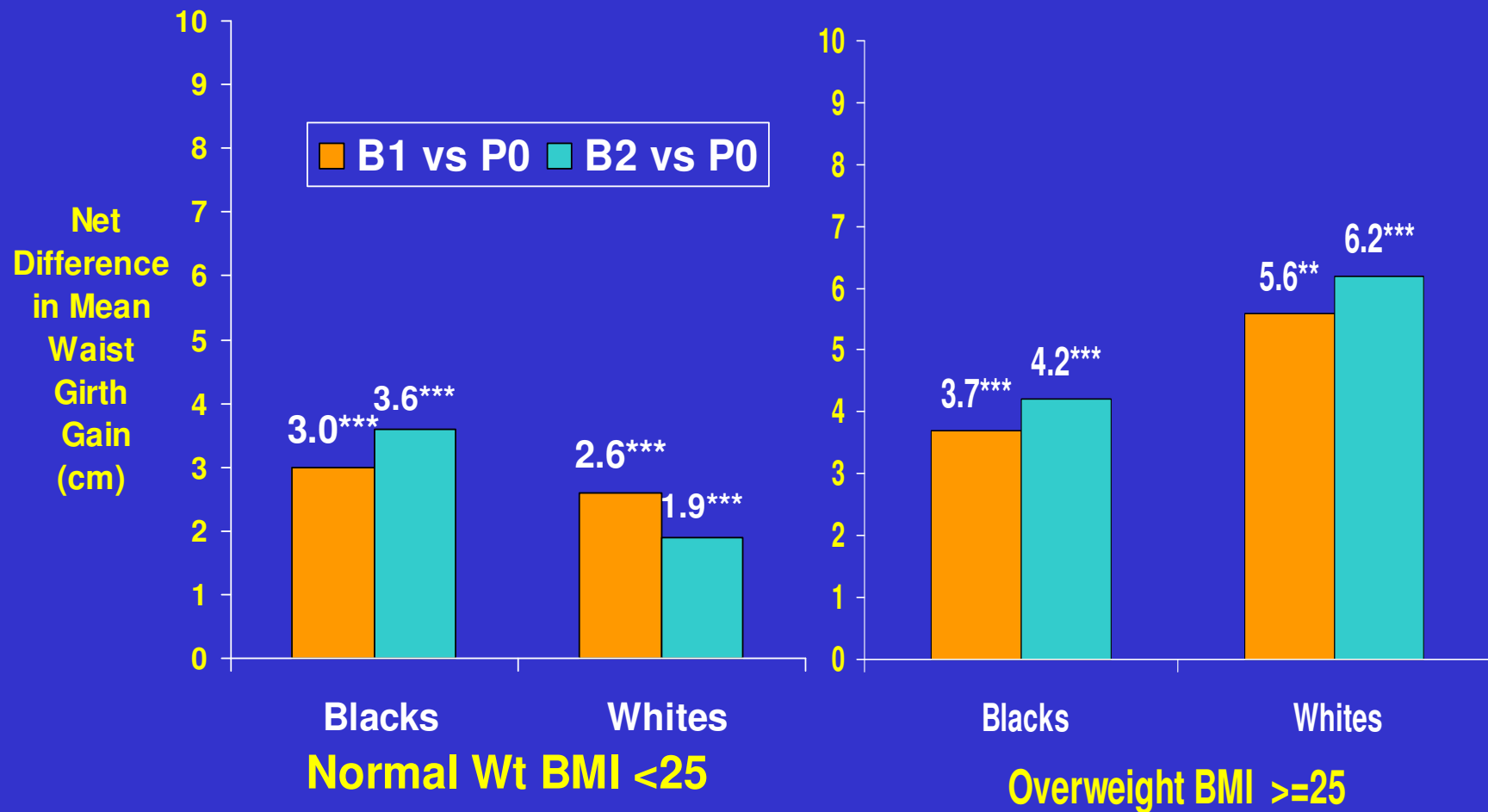
Author, Year Study	Parous, n (Primips)	Race, Age range	Study Period	Excess Weight Gain (kg)
Rosenberg, 2003 Black Women's Health Study, USA	1230 (598)	Black 21- 39 yr	4 Yrs (1995 – 99)	Primips > Nullips NL: 0.6 OV: 3.0 & above Gestational gain >25 lbs + 0.2 to 0.5 BMI

**Table 3: Prospective Studies: Childbearing and Abdominal Obesity
(nongravid referent & preconception measured waist girth) –
Excess increase in waist girth in 10 Yrs associated with births**

Author, Year, Study	Parous, n (Primips)	Race, Age range	Study Period	Change Abdominal Girth
Smith, 1994 CARDIA Study USA	203 (89)	Black/white 50% 18-30 yr	5 Yrs (1985-91)	<u>WHR</u> Primip >Nullips
Gunderson, 2004 CARDIA Study USA	845 (557)	Black/white 50% 18-30 yr	10 Yrs (1985-96)	<u>Waist (cm)</u> Primip >Nullips NL: 2- 3 OV: 3- 6 Multips: 2 - 4

NL = normal weight (BMI <25), OV = overweight (BMI ≥ 25) at baseline

Figure 2: Net differences in Adjusted Mean 10-Yr Excess Gain in Waist Girth (cm) by Interim Birth Groups (B1, B2+ vs P0) among Nulliparas at baseline by Race & BMI (Gunderson Int J Obes et al. 2004)



Childbearing
and
Long-term
Plasma Lipid Changes

Parity, Childbearing and HDL-C Declines

Cross-sectional studies: (pre- and post-menopausal)

Rancho Bernardo: - 4.9 mg/dl; 5+ births vs ≤ 4 births

Hispanic HANES: - 3.9 mg/dl; 6-8 pregs vs 0

Prospective studies (reproductive age)

Hubert et al., 1989 Framingham Offspring, 8 yrs - 1 mg/dl per birth

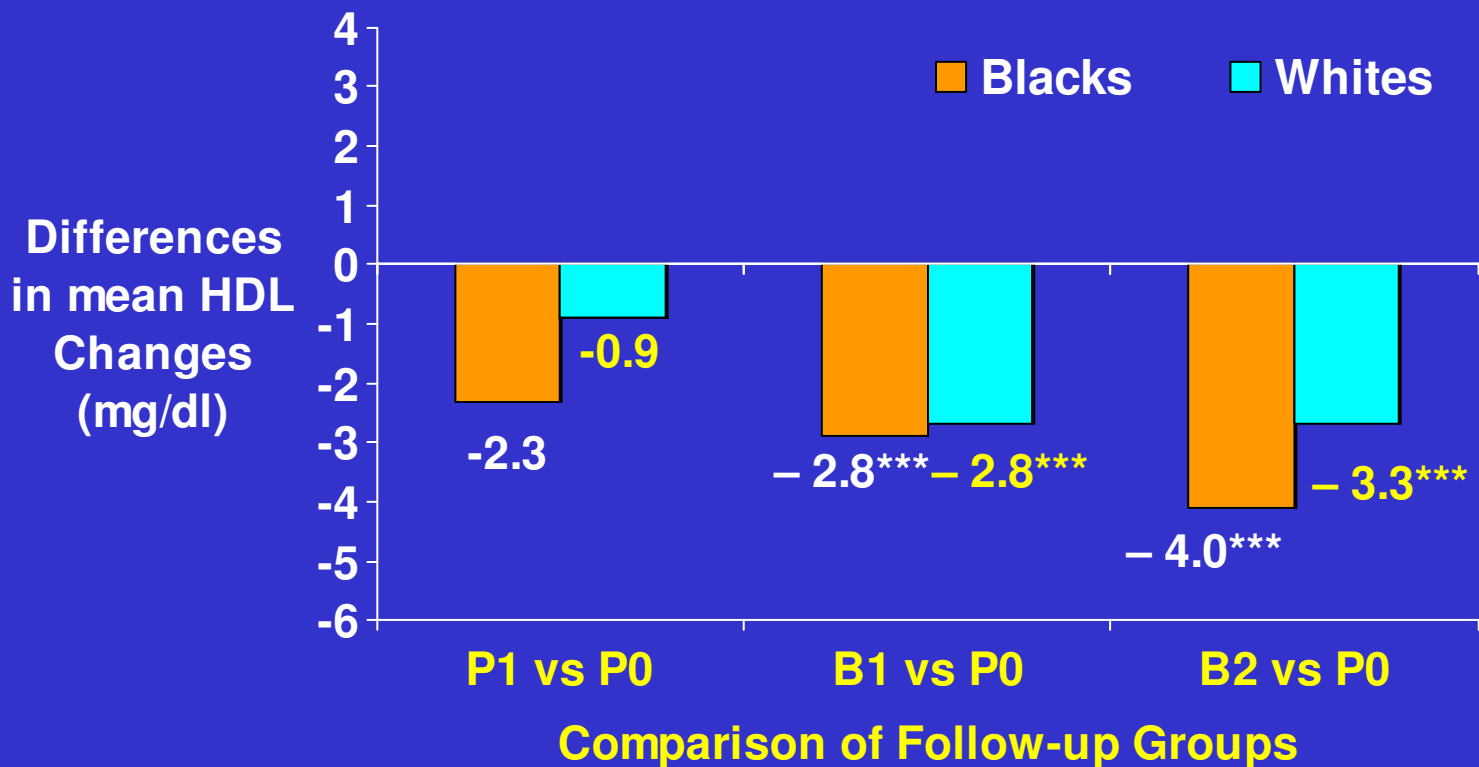
Haertel et al., 1992, 3 yrs - 2.4 mg/dl with 1+pregnancies

Lewis et al., 1996, CARDIA, 2 yrs - 3.5 mg/dl primip vs nullip

Gunderson et al., 2004 CARDIA 10 yrs - 3 to - 4 mg/dl primip vs nullip

Figure 2: Net Differences in Adjusted Mean 10-Yr Changes in HDL-C by no. of interim births B1 (1 birth) B2+ (2 + births) vs P0 (nongravid) among Nulliparas at baseline;

*p < 0.05; ** p < 0.01; *** p < 0.001. (Gunderson et al. AJE 2004)



Adjusted for center, age, height, baseline HDL-C, and time dependent variables (education, smoking status, physical activity, OC use, weight gain, waist girth)

Pregnancy, Childbearing
and
Future Chronic Disease

Table 1: Pregnancy cohort & Chronic Disease 15 Yrs Later

Author, Year Study	n, Follow-up (%)	Race,	Study Time interval	Risk Factors	Disease Outcomes
Rooney, 2005 Wisconsin USA	484/795 (61)	White	15 Yrs (1988 – 99)	High BMI F/U wt gain Smoking	13% DM or IGT 30% CHD, HTN or Dyslipidemia

Lifetime Parity and CHD Risk in Women

Cross-sectional:

Black Women's Health Study: (*Rosenberg et al. Obes Res 1999*)

High parity (≥ 7 births) and young age at first birth (< 20 yrs)

American Cancer Society 1981-89: (*Steenland et al. Epidem 1996*)

Weak + association; absent in BMI adjusted

Prospective:

Review (*Ness et al., 1994*) Older women,
30-90% increase in CHD events with gravidity ≥ 6 vs 0.

The Nurse's Health Study, 6 yr f/u (*Colditz et al., AJE 1987*)
no association with parity.

Lifetime Parity and Type 2 DM

Early retrospective studies,
women > 45 yrs of age: High parity (>5 births) with 3 to 6-fold DM
rates confounded by: cohort age/fertility, SES, BMI.

- 1 Non-diabetics: higher insulin and C-peptide levels for higher lifetime parity adjusted for BMI.
- 1 1990's Cross-sectional, population-based studies conflicting: associations adjusting for age, SES, BMI:
 - 3 (direct), 3 (null) in general populations &
 - 2 (inverse) in Native Americans.

Lifetime Parity and Type 2 DM- prospective

- 1 12-yr f/u (women 30-55 yr) Nurse's Health Study, no association with incident DM adjusted for age, BMI, Family Hx DM (*Manson et al., JAMA 1992*)
- 1 GDM women: 1 additional pregnancy 3-fold higher risk, independent of 2-fold higher risk per 4.5 kg gain. (*Peters et al., Lancet 1996*)

Childbearing and Chronic Disease in Women

- 1 Cumulative gains in abdominal obesity,
 - 1 Excess weight gain,
 - 1 Lower HDL-C levels independent of risk factors for CVD.
(Gunderson et al., AJE 2004, Gunderson et al., Int J Obes, 2004)
- 1 Weight gain during mid-life (>10 kg) with type 2 DM, CVD morbidity and mortality.
(Manson et al. NEJM 1995, Willet et al. JAMA 1995)
- 1 Inconclusive evidence of childbearing relation to CHD, Type 2 DM and the Metabolic Syndrome later in life.
- 1 Pregnancy may exacerbate future disease risk after GDM
(Peters et al., Lancet 1996)

Childbearing and Women's Health:

GREATEST EFFECTS AFTER **THE FIRST BIRTH**:

- ⌘ Pregravid Overweight:
Excess gain weight (3-6 kg) and waist girth (3-6 cm)
- ⌘ Lower HDL-C: – 3 to – 4 mg/dl not explained by adiposity gain;
Represents a 6 to 10% increase in CHD risk.
- ⌘ Normal BMI (1 kg mean): 2 to 3-fold higher risk of overweight

CUMULATIVE EFFECTS with BIRTHS:

- ⌘ Increases in waist girth with each higher order birth of 1-3 cm

RACE:

- ⌘ Similar childbearing effects by race (black, white).
- ⌘ Regardless of parity, black women are more likely to become overweight than white women.

Obesity Prevention

Interventions to prevent obesity in young women:

1. Ideally lose weight before conception if overweight or obese (43% women, CDC 2003)
2. Avoid gestational weight gain above IOM levels

Postpartum Interventions:

1. Focus on primiparas who are overweight/obese before pregnancy.
2. Normal weight with gestational gains above IOM
3. Vulnerable groups – GDM , HTN pregnancy

Future Research Directions:

- **Childbearing and chronic disease in women**
- **Preconception measures (overweight, obese)**
- **Gestational gain and chronic disease**
- **Postpartum patterns of weight (serial measures > 12 months)**
- **Abdominal adiposity**
- **Lactation**
- **Postpartum behaviors**
- **Race/ethnicity – esp. Hispanic and Asian**
- **Study Design- emphasis:**
 - **Reproductive age women**
 - **Nongravid comparison group**
 - **Preconception measures of risk factors**

ACKNOWLEDGMENTS:

- **Career Development Award, K01 DK059944
National Institute of Diabetes, Digestive and
Kidney Diseases (NIDDK)**
- **The American Diabetes Association**

Publications- Pregnancy and Long-term Weight Change

Billewicz WZ, Thomson AM. Body weight in parous women. *British Journal of Preventive Social Medicine* 1970; 24:97-104.

Harris HE, Ellison GT, Holliday M, Lucassen E. The impact of pregnancy on the long-term weight gain of primiparous women in England. *Int J Obes Metab Disord* 1997; 21:747-755.

Gunderson EP, Abrams B. The epidemiology of gestational weight gain and body weight change after pregnancy. *Epidemiol Rev* 1999; 21(2):261- 275.

Gunderson EP, Selvin S, Abrams B. The relative importance of gestational gain and maternal characteristics associated with the risk of becoming overweight after pregnancy. *Int J Obes Relat Metab Disord* 2000; 24(12):1660-1668.

Gunderson EP, Abrams B, Selvin S. Does the pattern of postpartum weight change differ according to pregravid body size? *Int J Obes Relat Metab Disord* 2001; 25 (6):853-862.

Linne Y, Rossner S. Interrelationships between weight development and weight retention in subsequent pregnancies: the SPAWN study. *Acta Obstet et Gyn Scand* 2003; 82(4): 318-325.

McKeown T, Record RG. The Influence of Weight and Height on Weight Changes Associated With Pregnancy in Women. *Journal of Endocrinology* 1957;15: 423-429.

Parker J, Abrams B. Differences in postpartum weight retention between black and white mothers. *Obstetrics and Gynecology* 1993; 81:768-774.

Rooney BL, Schauberger CW. Excess Pregnancy Weight Gain and Long-term Obesity: One decade Later. *Obstet Gynecol* 2002; 100:245-52.

Publications- Childbearing & Obesity

Williamson, DF, J Madams, E Pamuk, KM Flegal, JS Kendrick, MK Serdula. A prospective study of childbearing and 10-year weight gain in US white women 25 to 45 years of age. *Inter J Obes Relat Metab Disord* 1994;18: 561-569.

Smith, DE, CE Lewis, JL Caveny, LL Perkins, GL Burke, DE Bild. Longitudinal changes in adiposity associated with pregnancy. *JAMA* 1994; 271 (22):1747-1751.

Wolfe, WS, Sobal J, Olson CM, Frongillo EA, and Williamson DF. Parity-associated weight gain and its modification by sociodemographic and behavioral factors: a prospective analysis in US women. *Int J Obes Relat Metab Disord* 1997; 21(9):802-810.

Gunderson EP, Murtaugh MA, Lewis CE, Quesenberry CP, West DS, Sidney S. Excess gains in weight and waist circumference associated with childbearing: The Coronary Artery Risk Development in Young Adults Study (CARDIA). *Int J Obes Relat Metab Disord*. 2004;28(4):525-35.

Gunderson EP, Quesenberry CP, Lewis CE, Tsai AL, Sternfeld B, Smith West D, Sidney S. Development of overweight associated with childbearing depends on smoking habit: The Coronary Artery Risk Development in Young Adults (CARDIA) Study. *Obesity Research*, 2004;12(12):2041-53.

Publications- Childbearing & Chronic Disease

Pyke DA. Parity and the incidence of diabetes. *Lancet*. 1956;270:818-820.

O'Sullivan JB, Gordon T. Childbearing and diabetes mellitus. United States-1960-1962. *Vital Health Stat* 11. 1966 Nov;(21):1-19.

Manson JE, Rimm EB, Colditz GA et al. Parity and incidence of non-insulin-dependent diabetes mellitus. *Am J Med*. 1992;93:13-18.

Ness RB, Schotland HM, Flegal KM, Shofer FS. Reproductive history and coronary heart disease risk in women. *Epidemiol Rev* 1994;16:298-314.

Peters RK, Kjos SL, Xiang A, Buchanan TA. Long-term diabetogenic effect of single pregnancy in women with previous gestational diabetes mellitus. *Lancet*. 1996;347:227-230.

Gunderson EP, Lewis CE, Murtaugh MA, Quesenberry CP, Smith West D, Sidney S. Long-term plasma lipid changes associated with a first birth: The Coronary Artery Risk Development in Young Adults Study. *Am J Epidemiol*. 2004;159(11):1028-39.

Gunderson EP, Whitmer RA, Lewis CE, Quesenberry CP, Smith West D, Sidney S. Do HDL-C Declines Associated With a First Birth Vary by Apo E Phenotype? The Coronary Artery Risk Development in Young Adults Study (CARDIA). *Journal of Women's Health*. 2005;14(10):917-28.